CHEM-342 Introduction to Biochemistry
Mid-term Examination - Group Part
Friday, 23 March 2012
H. B. White - Instructor
30 Points

Group Members ___**ANSWER KEY1**__

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Range = 15 – 22/30 Average = 17.5/30

Important - Please read this before you turn the page.

- You must sign your name on this page to receive the group grade.
- You may refer to your notes, course reader, handouts, or graded homework assignments. Reference books in the course library may be consulted briefly and returned.
- In CHEM-342, hemoglobin is a vehicle for learning how to learn by asking questions and pursuing answers to those questions. Undoubtedly you have learned a lot about hemoglobin in the process, but you also should be developing habits of mind that will enable you to solve problems in other courses and throughout your life. This part of the midterm examination provides an opportunity for you and the other members of your group to display problem-solving skills as a team. It is unlikely that anyone in your group or in the class has encountered the information in the video you will see. Your answers should display your collective:
  - breadth of knowledge (not limited to hemoglobin or biochemistry)
  - ability to analyze, make connections, and ask probing questions
  - sense of logic and organization
  - skill at generating models (testable hypotheses)
- This examination should be approached in phases
  1. **Phase 1** - Individual work for 10 to 15 minutes. Pay careful attention to the video and write down all of your learning issues and thoughts.
  2. **Phase 2** - Then, as a group, generate as long a list of learning issues as you can (≥5). Organize your learning issues into categories and arrange them to display a probing series of connected questions.
  3. **Phase 3** - Generate a hypothesis provoked by the data and built around one of your learning issue categories. Make a prediction about the results of a test you generate for your hypothesis.
- This examination will be evaluated on the richness of learning issues, the depth of analysis, the presentation of learning issues, and the quality of hypotheses and tests.

The class will be shown the first 5 minutes of a short movie recently produced by HHMI. Please pay careful attention to the movie. You may take notes.”Making of the Fittest: The Birth and Death of Genes” < http://www.hhmi.org/biointeractive/shortfilms/>

1. (10 Points) Generate a list of ***at least five***, well-articulated and distinct learning issues relating to the video.

There are about four key observations revealed in the short video clip.

- The crocodile fish lives in very cold water
- It lacks scales
- It has colorless blood
- It has white internal organs and gills

Substantive learning issues should develop from these observations and attempt to link them in some rational way based on prior knowledge. All of the above can be connected to oxygen and oxygen transport in one way or another.

a. The crocodile fish lives in very cold water (Sea water freezes at -1.8°C.) The solubility of gases (oxygen) in liquids (water) increases with lower temperatures (Henry's Law), so the Antarctic waters should be well oxygenated. Metabolic rates decrease with temperature. Fish are cold-blooded. Does the crocodile fish in fact have a low metabolic rate and a relative abundance of dissolved oxygen compared to fish living in warmer waters? What is its metabolic rate? What is the solubility of oxygen in sea water and blood as a function of temperature?

b. Most fish have scales. Other scaleless vertebrates include amphibians, such as frogs, that can overwinter (aestivate) for months under water at low temperatures when they have a low metabolic rate and can absorb oxygen through their skin. (However, they do have hemoglobin.) By analogy, does the absence of scales enable the crocodile fish to augment the oxygen absorption that takes place in the gills?

c. Blood in vertebrates is intensely colored whether it is oxygenated or not. The fact that the crocodile fish has colorless blood indicates that it lacks hemoglobin and perhaps red blood cells. Either the crocodile fish is able to live without hemoglobin or has some other molecule that serves as an oxgen transporter. Does this fish have a different oxygen transporter? If so, what is it?

d. If the crocodile fish has a different oxygen transporter, it has to be colorless. That would suggest that it doesn't contain iron, a metal that forms colored compounds and does not contain a heme-like organic molecule with lots of conjugation associated with colored organic compounds. One could postulate, that Antarctic waters are deficient in iron and thus the ice fish has selected an alternative oxygen carrier. Are there any unusual or undescribed proteins or other compounds in the blood of the crocodile fish that might be oxygen transporters?

e. If the blood from the crocodile fish lacks an oxygen transporter, what are the implications? It would mean that blood saturated with oxygen in the absence of an oxygen carrier is sufficient to sustain oxidative metabolism. How might this fish adapt to this situation? Does the crocodile fish's blood circulate faster through the gills and near the skin so that it picks up more

oxygen faster? Is the crocodile fish sedentary and lie on the bottom thereby reducing its oxygen needs while not swimming? Does the crocodile fish have fewer mitochondria and a greater glycolytic capacity?

f. Hemoglobin is not the only colored compound found in vertebrate tissues, yet the organs of the crocodile fish are white suggesting that other colored compounds might also be absent as well, e.g. myolobin—an oxygen-binding protein in muscles an hearts of other vertebrates. Similarly, mitochondria contain many colored proteins which might suggest that mitochondria are scarce. Is this so?

g. Evolutionary adaptations found in one organism often are observed in other organisms living in the same environment. Consider the white fur and feathers of vertebrates living in the arctic. Are changes observed in the crocodile fish seen in other organisms living in Antarctic ((or Arctic) waters? For example, if hemoglobin is not lost are these animals "anemic"? If so, is there a correlation between the amount of hemoglobin, temperature, and metabolic activity?

h. Hemoglobin is the target of carbon monoxide poisoning. Without hemoglobin, is this fish less sensitive to carbon monoxide poisoning? This fish is probably does not encounter carbon monoxide, so it would not be a selective reason to lack hemoglobin, but it might enable the fish to live in environments toxic to other organisms.

i. How do these fish manage to live at the freezing temperature of sea water? Blood is not as concentrated as sea water and thus would be expected to freeze.

j. Presumably the crocodile fish had ancestors that could produce hemoglobin and have lost that ability. It is possible that an inactive or silenced hemoglobin gene still exists in the genome of the ice fish. Does the crocodile fish have a gene for hemoglobin, but not express it?

k. What are the closest relatives of the crocodile fish? Do they share any similar traits such as living in cold water, lacking red blood, or lacking scales. If there is a range of similarities and a phylogeny based on DNA could be constructed, it might be possible to deduce the evolutionary history of the crocodile fish's adaptations.

2. (10 points) Pick your best five learning issues. Write a short explanation about why your group thinks each is important or of significance rather than an idle curiosity.

The answer to this question is embedded in each of the learning issues above.

3. (10 points) Pick one of your learning issues to expand into a biochemical research plan that incorporates some detail on how you would proceed and identify some challenges that might be encountered.

Many possible answers depending on the learning issue selected.